

**RISKS TO HUMAN HEALTH
ASSOCIATED WITH WATER AND FOOD CONTAMINATED
WITH ANIMAL WASTES**

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A BRIEF

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Introduction

Animal fecal wastes/ manure may contain pathogenic microorganisms that once applied to land can run off into water, contaminate soil/or crops and spread disease to humans. In the spring of 2004, the US Court of Appeals for the Second Circuit ruled that the US Environmental Protection Agency must establish a standard for “pathogen reduction” for Confined Animal Feeding Operations (CAFOs) and that the process of establishing that standard must provide adequate opportunity for public participation. Figure 3-7 from the USDA Agricultural Waste Management Field Handbook (1992) shows the pathways for nutrients to move from manure into the water environment. Bacteria, parasites and animal viruses will follow these same pathways contaminating potentially both ground and surface waters. Yet their concentrations, survival and the risk to human health will be very different from nutrients. The production of a pathogen standard should be science-based and risk-based so that public health protection would be assured. Risk reduction strategies are used for microorganisms/pathogens to govern the application of human biosolids to land; thus, while approaches are available to monitor, assess and reduce risks, these approaches have not been applied to animal fecal wastes applied to land (Federal Register, 1993).

Waterborne disease in humans is primarily associated with pathogens that originate from animal and human fecal wastes, transmitted to humans via contamination of drinking water and recreational water (Dewailly et al. 1986; Fewtrell et al. 1992). There have been a number of studies that have shown illness occurs even with boating and canoeing and general contact. Foodborne disease also occurs often due to the fecal contamination of vegetables and fruits.

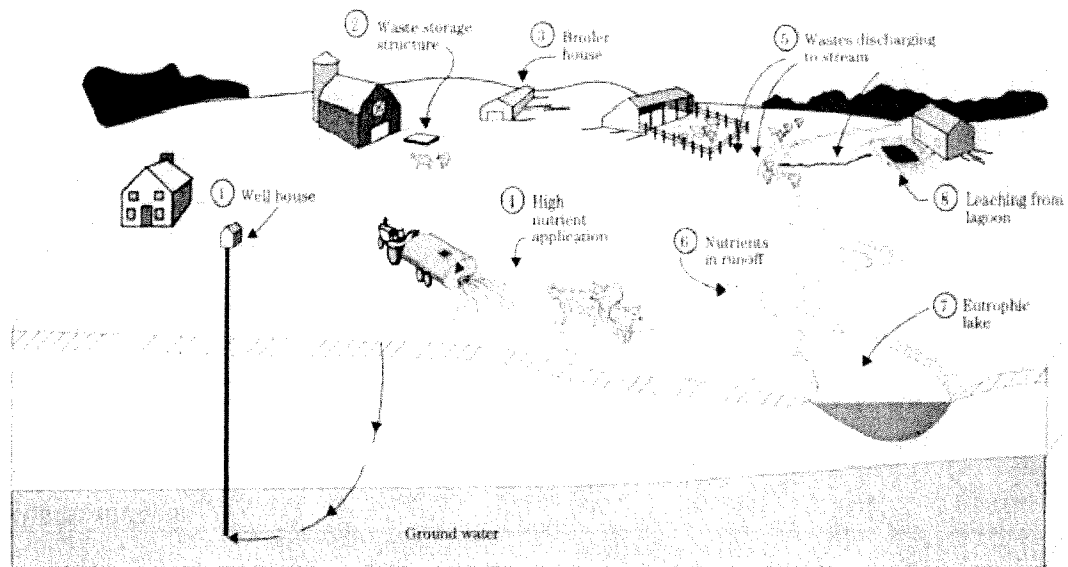
- Outbreaks of disease associated specifically with animal manure have been documented (Table 1; Guan and Holley, 2003); this includes both foodborne and waterborne disease.
- The outbreak of *E.coli*0157H7 in Walkerton, Ontario occurred due to the contamination of ground water via manure as well as inappropriate chlorination. This outbreak lead to 6 deaths and chronic disease problems in this community and many of the children may need kidney transplants in the future (Krewski et al., 2002).
- *Cryptosporidium* a pathogenic protozoan parasite has also been associated with disease spread from animals to humans.
- Fecal coliform bacteria and other pathogens are one of the top causes of impairment to water quality in the US and it is estimated that manure is a large source of this impairment (EPA, 2002).

Table 1: Examples where manure has been implicated as the source of pathogens (Guan and Holley, 2003).

Location and date	Type of manure	Pathogen(s)	Human morbidity and mortality
1979-1981, Maritime Provinces, Canada	Sheep manure±	<i>Listeria monocytogenes</i>	34 cases of perinatal listeriosis and 7 cases of adult disease
July 1985, UK	Cow manure±	<i>Escherichia coli</i> 0157: H7	49 cases including 1 death
24 Oct.-20Nov. 1991, southeastern Massachusetts	Cattle manure±	<i>E. coli</i> 0157: H7	23 cases and no deaths
23 Sept.-1 Oct. 1992, Maine	Cow and calf manure±	<i>E. coli</i> 0157: H7	1 death and 4 cases
October 1992, Africa	Cattle carcass and manure±	<i>E. coli</i> 0157: H7	Thousands of cases and some deaths
March-April 1993, Milwaukee, WI	Cattle manure±	<i>Cryptosporidium</i>	403,000 cases
October 1993, Maine	Calf manure	<i>Cryptosporidium</i>	160 primary cases
Summer, early 1990s, Germany	Hog manure±	<i>Citrobacter freundii</i>	1 death, 8 HUS, 8 gastroenteritis cases and 20 asymptomatic cases
4 June 1995, Ontario, Canada	Cattle manure±	<i>E. coli</i> 0157: H7	1 case of bloody diarrhea
June 1996, New York	Poultry manure±	<i>Salmonella Hartford</i> and <i>Plesiomonas shigelloides</i>	About 30 cases and 1 hospitalization
June-July 1997, Somerset, UK	Cow manure§	<i>E. coli</i> 0157: H7	8 cases
Summer 1999, Scotland, UK	Sheep manure§	<i>E. coli</i> 0157: H7	6 cases
May-June 2000, Ontario, Canada	Cattle manure§	<i>E. coli</i> 0157: H7 and <i>Campylobacter</i> spp.	6 deaths and 1346 reported cases
March-May 2001, Saskatchewan, Canada	Animal or human waste±	<i>Cryptosporidium parvum</i>	1907 cases and no deaths

± Suspected as the source of contamination.

§ Confirmed as the source of contamination.

Figure 3-7 Possible danger points in the environment from uncontrolled animal waste

1. Contaminated well: Well water contaminated by bacteria and nitrates because of leaching through soil. (See item 4.)
2. Waste storage structure: Poisonous and explosive gases in structure.
3. Animals in poorly ventilated building: Ammonia and other gases create respiratory and eye problems in animals and corrosion of metals in building.
4. Waste applied at high rates: Nitrate toxicity and other N related diseases in cattle grazing cool season grasses; leaching of NO_3^- and micro organisms through soil, fractured rock, and sinkholes.
5. Discharging lagoon, runoff from open feedlot, and cattle in creek: (a) Organic matter creates low dissolved oxygen levels in stream, (b) Ammonia concentration reaches toxic limits for fish, and (c) Stream is enriched with nutrients, creating eutrophic conditions in downstream lake.
6. Runoff from fields where livestock waste is spread and no conservation practices on land: P and NH_4^+ attached to eroded soil particles and soluble nutrients reach stream, creating eutrophic conditions in downstream lake.
7. Eutrophic conditions: Excess algae and aquatic weeds created by contributions from items 5 and 6, nitrite poisoning (brown blood disease) in fish because of high N levels in bottom muds when spring overturn occurs.
8. Leaching of nutrients and bacteria from poorly sealed lagoon: May contaminate ground water or enter stream as interflow.

Occurrence of Pathogens in Animal Wastes and Types of Diseases

There are numerous bacteria and protozoan pathogens, which can be found in animal wastes that affect human health and the health of other animals. Surveys have shown that between 10 to 50% of the animals at any one time are excreting one or more pathogen (Table 2).

Animals can excrete huge numbers of pathogens, estimates range from 1 million to 10 million per gram (Dorner et al., 2004). For example, excretion of *Cryptosporidium parvum* can occur at concentrations of up to 10,000,000 per gram and 10 billion per day, typically for 3-12 days (Atwill, 1998).

Table 2. Pathogens found in 10 to 50% of the animals during various surveys:

Animal	Pathogen	Pathogen isolated from
Cattle	<i>Salmonella</i> , <i>Listeria</i> , <i>E. coli</i> O157, <i>Campylobacter</i> , <i>Cryptosporidium</i> and <i>Giardia</i>	Cattle manures
Pigs	<i>Salmonella</i> , <i>Listeria</i> , <i>E. coli</i> O157, <i>Campylobacter</i> , <i>Cryptosporidium</i> and <i>Giardia</i>	Pig manures
Poultry	<i>Salmonella</i> , <i>Campylobacter</i>	Poultry manure
Sheep	<i>Salmonella</i> , <i>E. coli</i> O157, <i>Campylobacter</i> and <i>Cryptosporidium</i>	Sheep manure

Survival in the Environment

The available literature suggests that *temperature* is the single most important factor that determines pathogen survival times in manures and the wider environment. In general, pathogens are destroyed after a short time at high temperatures (>55°C, 130°F) and some by freezing, although most data in the environment shows that many pathogens survive over the winter. However, even at low to moderate temperatures pathogen numbers will decline over time, especially under very dry conditions or on exposure to UV radiation. Survival in wet cool climates is extended.

Pathogens found in livestock manures can survive in the soil for months or years after spreading or excretion onto land (Nicholson et al., 2004). Temperature was identified as being the most important factor and pH, UV light and drying also contributed to some reduction. Control of the risk associated with pathogen transfer into the food chain included treatment, extended storage and no harvest periods following land spreading.

Studies in Michigan found *Cryptosporidium* in 11 surface water sites near CAFO farms which may have been the source of the oocysts. The site with the highest detected level of *Cryptosporidium* was at the white tile that drains into Rice Lake Drain near the Haley Road crossing with levels as high as 5990 oocysts per 10L. *Giardia* was detected at 8 of the surface water sites. Viable and infectious oocysts were also detected. High levels of *E.coli* bacteria were reported as well (Rose, JB, Water Quality and Health Laboratory, Michigan State University, E. Lansing MI).

Importance of infectious dose

The infectious dose is that concentration of organisms that will initiate an infection in a specific proportion of the population exposed. Often one uses what is termed the ID₅₀, the dose that causes infection in 50% of the people exposed. Dose-response data developed in human volunteers was developed for many enteric bacteria, parasites, including *Cryptosporidium*, and viruses (Haas et al., 1999). The data shows that even one organism is capable of initiating an infection and that very low numbers of parasites and viruses in water, if ingested, respired or exposed to the hands can cause an infection.

While the parasites are more infectious at low doses than the bacteria, the bacteria mentioned above can grow on crops and in soil. In addition, bacteria such as *Campylobacter* and *E.coli* 0157H7 are highly infectious, so that low doses (10 to 100 cells) can cause a high probability of infection.

Other Issues associated with Manure Contamination in the Environment

The use of antibiotics to improve animal health and productivity has been increasing since the 1970's (McDermott et al., 2002). According to a 2000 survey from the Animal Health Institute, in the US alone, 32.2 million pounds of antibiotics (64.5%) were used for food products used for human consumption, 14.7 million pounds (29.5%) for therapeutic and non-therapeutic practices in livestock, and 3.1 million pounds (6%) for growth promotion (Animal Health Institute, 2002). According to more recent data from the same group, the use of antibiotics as growth promoter rose to 13% in 2003. The non-therapeutic use of antibiotics for animals has been reported in approximately 70% of large swine feedlot operations and 25% in small feedlot operations (APHIS web site). More than 70% of large cattle feedlot use antibiotics in at least 58% of their heads. An astonishing 88% of large dairy operations administered antibiotics to up to 40% of their cows during lactation periods.

Correspondingly, both veterinary and human antibiotics are being detected in waters throughout the US (Kolpin et al., 2002) and evidence of spread of antibiotic resistance (AR) is also emerging. Approximately 50% of the streams were contaminated with a range of antibiotics and Erythromycin-H₂O, a metabolite of erythromycin, was the most frequently reported (found at a 21% frequency). Our research team at MSU has found new classes of tetracycline resistance in tetracycline-treated manure soils.

The Risk Assessment Paradigm

A risk assessment science based method is needed to examine the risks and to address control in an appropriate manner. The human health risks and infectious disease risks from animal wastes are clear and have been documented. Other issues are pending, such as antibiotic resistance. The animal population as is the human population is growing and so is the amount of wastes that need to be disposed of. Land-application should be done safely in a manner that will protect public health.

We now know that:

- Zoonotic infections are those that move from animals to humans and are now playing a central role in emerging infectious disease in humans (from *Cryptosporidium* to *E.coli* to Ebola to Bird Flu).
- Many emerging zoonotic diseases are transmitted by indirect contact—foods, water, environmental contamination, vectors, etc. and are not reliant on direct contact between human and animal hosts for transmission.
- Tonnage of animal waste has been estimated and controlled based on nitrogen in animal excreta yet little effort has been made to address the microbial and zoonotic infectious disease potential due to loading of manure onto land.

We should use quantitative microbial risk assessment to address the future needs for “safe” application of manure to land to avoid disease spread. To conduct a risk assessment, key pieces of information are required to be known, or at least predictable, based on mathematical models: 1) the infectious dose of the pathogen of interest; 2) the concentration at which the agent can be found in manure, and 3) the impact of various treatment/storage strategies on the reduction in infectivity of the pathogen of interest 4) survival in the environment 5) transfer potential to food chain, water air or directly to people. The data and the framework are appropriate and can be used to make sound regulations.

Conclusions

- Animal manures contain pathogens that can and have been shown to spread disease to humans. Spread of animal manure on land without assessment and oversight presents a risk to public health.
- Occurrence, survival, and reduction of pathogens in manures by appropriate controls should be addressed.
- The Risk Framework can be used to estimate the necessary pathogen reduction goals necessary to protect public health.
- Emerging risks, such as antibiotic resistance, should be taken into account.

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